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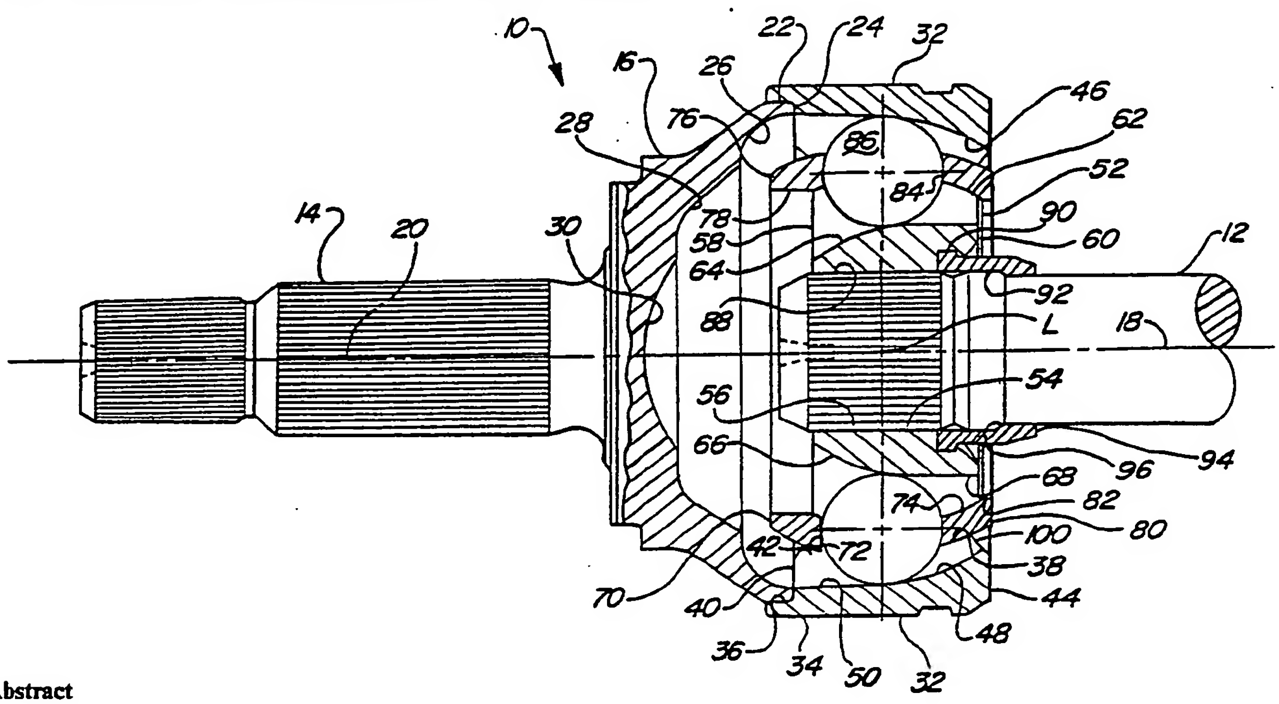

(57) Abstract

A constant velocity universal joint for transmitting driving torque between rotative members, such universal joint including a hub fixed to one of the rotative members and an outer joint member attached to the hub, an inner joint member attached to another one of the rotative members and a ball containing cage positioned between the outer joint member and the inner joint member. The balls are engaged in ball races positioned in the outer joint member and in the inner joint member. The ball races are sloped so as to provide maximum material at the location of highest stress, the major ball races being of the undercut free design.

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UNDERCUT FREE CONSTANT VELOCITY JOINT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a constant velocity universal joint for use in any application requiring torque transmission through a varying angle. More particularly, the invention involves a universal joint that utilizes a plurality of balls to transmit a torque from an inner joint member to an outer joint member. The interior of the outer joint member contains a series of grooves that are in radial alignment with a complementary series of grooves that are positioned on the exterior of the inner joint member. A cage is positioned between the outer joint member and the inner joint member to guide the balls as they traverse the grooves during articulation of the universal joint.

2. Description of the Prior Art

The prior art reveals a wide variety of devices that permit the transmission of a rotational torque from one shaft that is angularly displaced with respect to another shaft coupled thereto. In general, most of the prior art devices require extensive machining of the individual parts to assure satisfactory assembly and operation of the device. Then, too, the overall strength of the prior art devices was compromised by the required machining of the individual parts.

The present invention differs from the undercut-free constant velocity joint that is shown and described in U.S. Patent No. 3,879,960, entitled "Constant Velocity Joint" issued April 29, 1975, to Hans-Heinrich Welschof et al. The constant velocity joint described in the above-referenced patent shows an outer joint member in which the individual ball grooves are divergent with respect to the central axis of the universal joint, when viewed from the open end of the outer joint member. The ball grooves that are positioned in the inner joint member are convergent with respect to the central axis of the universal joint. The balls are maintained in a spaced apart planar

joint. The balls are maintained in a spaced apart planar relationship with one another by means of a cage that is positioned between the outer joint member and the inner joint member. The outer joint member does not lend itself to press forging techniques since the opening therein is of smaller diameter than the diameter of the interior cavity therein. Also, the lip of the outer joint member is thin because of the divergent nature of the ball grooves. The thin areas of the outer joint member occur at one of the areas of maximum stress in the universal joint, particularly when large angles of articulation are employed.

Thus, the present invention differs from the above-described universal joint in that the divergence and convergence of the ball grooves in the outer joint member and the inner joint member are in reverse order. Then, too, the free end of the outer joint member is of increased thickness in the present invention.

In U.S. Patent No. 4,188,803, entitled "Constant Velocity Universal Joint" issued February 19, 1980, to Nobuyuki Otsuka et al, there is shown a universal joint that employs an input and an output shaft. The output shaft has a cavity containing hub into which is fitted the end of the input shaft. The input shaft contains an inner member attached thereto. The inside of the hub and the outside of the inner member contain ball grooves. A ball cage is positioned between the hub and the inner member. The ball cage is unique in that its inside and outside surfaces contain spherical surfaces that are eccentric instead of the usual concentric spherical surfaces. The ball cage is supported on spherical surfaces that are also eccentric.

The present invention utilizes only concentric spherical surfaces which are easier to form. Further, the present invention does not have any undercuts that must be made in the hub area as does the above reference. The ball cage of the present invention is quite simple with concentric spherical surfaces being employed.

Also, the hub and inner torque members utilize concentric spherical surfaces.

Another example of the prior art is shown in U.S. Patent No. 4,610,643, entitled "Rotary Constant Velocity Universal Joint" issued September 9, 1986, to Werner Krude. The universal joint shown in the patent 4,610,643 has an outer joint member in which the ball grooves are convergent as viewed from the open end of the outer joint member and the grooves in the inner joint member are divergent. This arrangement or slope of the grooves is just the opposite to that seen in the previously discussed patent 3,879,960. The outer joint member is separate from the axle-hub combination with which it coacts. A cylindrical sleeve unites the outer joint member to the hub by welding and crimping techniques. A ball cage supporting element is used to retain the balls in the grooves to engage the balls on one side. The ball cage supporting element does not contact the spherical surfaces of the outer joint member or the inner joint member, but instead, the ball cage contacts a spherical surface 30 in the interior of the joint near the central hub as shown in Figure 1. In the above-described patent, the ball cage contains a series of fingers that are intercalated with respect to the balls. This universal joint requires extensive machining to fabricate the joint as well as complicated tools for fabricating the various details.

The present invention is an improvement over the universal joint shown and described in the patent 4,610,643, in that fewer parts are utilized and there is less frictional contact with the ball cage. Additionally, the present invention provides a ball cage with apertures therein that completely circumscribes each ball. Further, by providing a universal joint with an outer joint member having a thick structural section near its open end, the area of highest load concentration upon articulation, the joint is more reliable and durable. The outer joint member fabrication is simplified and the cost of fabrication is significantly reduced.

SUMMARY OF THE PRESENT INVENTION

The present invention is a constant velocity universal joint for use in transmitting a driving torque from a first axial direction to another axial direction, angularly disposed with respect to the first direction.

The invention includes an outer joint member that contains a plurality of axially extending grooves therein. An inner joint member is positioned within the outer joint member and a plurality of mutually dependent grooves are carried by the inner and outer joint members. The outer joint member is coupled to a hub that is formed as an integral part of a first torque transmitting shaft and a plurality of balls are held in planar relationship to one another by a cage that is positioned between and in contact with the outer and inner joint members. A second torque shaft is coupled to the inner joint member by any convenient disconnect means.

A primary object of the present invention is to provide a universal joint that requires a minimum amount of machining in the manufacture thereof.

Another object of the present invention is to provide a universal joint in which the major components are undercut-free.

A further object of the present invention is to provide a design that lends itself to cold impact press forming of the parts of the universal joint.

Another object of the present invention is to reduce the contact area of the ball cage with the outer joint member and the inner joint member of the universal joint.

Still another object of the present invention is to provide a universal joint with enhanced strength characteristics.

A further object of the present invention is to provide a universal joint that is easy to assemble and disassemble.

Further objects and advantages of the present invention will become apparent from the following description and the appended claims, reference being made to the accompanying drawings

forming a part of this specification, wherein like reference characters designate corresponding parts in the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1A is a part sectional view of a prior art undercut-free outer joint member;

Figure 1B is a graphical representation of the prior art under-cut free constant velocity joint forces experienced in the ball track as the bending angle increases.

Figure 1 is a part sectioned side view that shows the universal joint of the present invention;

Figure 2 is a part sectioned side view that shows the universal joint in an angular drive attitude;

Figure 3 is a part sectioned side elevational view of the integral hub and output shaft;

Figure 4 is an end view of the hub and output shaft as viewed along lines 4-4 of Figure 3;

Figure 5 is an elevational end view of the outer joint member that shows the pairs of grooves positioned on the interior surface thereof;

Figure 6 is a sectioned view taken along section lines 6-6 of Figure 5 which shows the curvilinear surfaces for the balls and the cage;

Figure 7 is an end view of the inner joint member that shows the pairs of grooves positioned on the exterior surface of the inner joint member; and

Figure 8 is a sectioned view taken along section lines 8-8 of Figure 7 that shows the curvilinear surfaces for the balls and the cage.

It is to be understood that the present invention is not limited to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways within the scope of the claims. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and not of limitation.

DETAILED DESCRIPTION OF THE PRFFERRED EMBODIMENT

Referring to the drawings and more particularly to Figure 1A, there is illustrated a prior art undercut-free constant velocity universal joint in part section view that has application for many uses such as the coupling of drive shafts and other applications. The graph illustrated in Figure 1B represents the forces experienced in the outer joint member as the bending angle increases. The bending is the angle of articulation between the central axis of the outer joint member and the central axis of the inner joint member. The graph clearly shows that the greatest forces are experienced at maximum bending angle and in the area near the open end of the outer joint member.

Figure 1 is a part sectioned side elevational view that shows the universal joint of the present invention. The overall apparatus is identified by the numeral 10 as shown. For purposes of illustration it will be assumed that a rotational force or torque is applied to an input shaft 12 which is shown at the right-hand side of$Figure 1. An output shaft 14 is positioned at the left-hand side of the overall apparatus 10. Of course, the flow of torque could be in a direction opposite to that above stated. The output shaft 14 is coupled to a hub 16 that can be, as shown, an integral part of the output shaft 14. The hub 16 and the output shaft 14 are coaxial along an output axis 20. An input axis 18 is shown coincidental with the output axis 20. The hub 16 has a cylindrical external surface 22 that abuts a radially inward lip 24. The lip 24 is planar and is perpendicular to the output axis 20. The hub 16 has a concavity that is formed by an arcuate section 26, a frustoconical section 28, and a spherical section 30. The blending together of the above three sections produces a concavity that can be readily formed by press and forge techniques.

An outer joint member 32 has an exterior surface 34 that is cylindrical about the output axis 20. The left-hand end of the outer joint member 32, as viewed in Figure 1, has an internal

cylindrical surface 36 of shorter radius than the exterior surface 34. The internal cylindrical surface 36 of the outer joint member 32 coacts with the cylindrical external surface 22 of the hub 16 in order to couple the hub 16 and the outer joint member 32 in a manner to be more fully described hereinafter. The outer joint member 32 has an interior spherical surface 38. The interior spherical surface 38 is defined by a radius that has its locus situated on the input axis 18 at a point L. The left-hand end 40 of the outer joint member 32 is planar in configuration and has a radial extent spanning the distance between the internal cylindrical surface 36 and the interior spherical surface 38. The juncture between the end 40 and the interior spherical surface 38 can be beveled as identified by the number 42. The right-hand end 44 of the outer joint member 32 has a planar configuration and has a radial extent that extends between the exterior surface 34 and the interior spherical surface 38. The juncture between the end 44 and the interior spherical surface 38 is beveled at approximately 45° as will be commented on elsewhere. Thus, it is evident that a large cavity passes through the central axial region of the outer joint member 32.

A plurality of axially extending arcuate ball races or grooves 46 is cut into and through the interior spherical surface 38 of the outer joint member 32. The mid line or, the most radially outward extent of each ball race has a circular section 48 that is coupled to an essentially linear section 50. The circular section 48 has a radius with a locus that is positioned on the output axis 20 to the left of the point L. The ball races 46 are positioned diametrically with respect to each other as is shown in Figure 5. Each pair of diametrically opposed ball races 46 has their mid lines lying in a plane that also contains the output axis 20.

An inner joint member 52 is positioned within the open cavity that passes through the outer joint member 32. The inner joint member 52 is positioned symmetrically about the input axis

18. The inner joint member 52 has an internal cylindrical bore 54 that is equipped with axially extending splines 56. The inner joint member 52 has radially extending left and right-hand essentially planar ends 58 and 60. The most radial exterior surface 62 of the inner joint member 52 is spherical in configuration with the spherical extent terminating at the juncture with the planar ends 58 and 60.

The inner joint member 52 contains a plurality of axially extending arcuate ball races or grooves 64 that are cut into and through the exterior spherical surface 62. The mid line or, the most radial inward extent of each ball race 64 has a circular section 66 that is connected to an essentially linear section 68. The circular section 66 has a radius with a locus that is positioned on the input axis 18 to the right of the point L. The distance of the locus of the circular section 66 from the point L should be essentially equal to the distance of the locus of the circular section 48 of the outer joint member from the point L.

A ball cage 70 is positioned within the cavity of the outer joint member 32 and is spaced exteriorly of the inner joint member 52 in telescoped arrangement. The ball cage 70 has exterior and interior spherical surfaces 72 and 74 that are concentric with one another. The exterior spherical surface 72 is terminated at its left-hand end, as viewed in Figure 1, by a radially inwardly extending end 76. The most radially inward portion of the end 76 intersects an axially extending cylindrical bore 78. The cylindrical bore terminates at its right-hand end with an intersection with the interior spherical surface 74. The exterior spherical surface 72 of the ball cage 70 terminates at its right-hand end by a radially inwardly extending end 80. The most radially inward portion of the end 80 intersects an axially extending cylindrical bore 82. The cylindrical bore 82 terminates at its left-hand end with an intersection with the interior spherical surface 74.

The exterior spherical surface 72 of the ball cage 70 is in rotational contact with the interior spherical surface 38 of the outer joint member 32. In a similar manner, the interior spherical surface 74 of the ball cage 70 is in rotational contact with the exterior spherical surface 62 of the inner joint member 52.

A plurality of radially extending bores or windows 84 is positioned in the wall created by the exterior and interior spherical surfaces 72 and 74 of the ball cage 70. The axes of the bores 84 pass through the point L on the input shaft 12. Each axis 84 is coincident with the mid line of the ball races 46 and 64. In other words, the axis of each bore 84 lies in a plane that contains the mid lines of each pair of mid lines associated with the ball races 46 and 64.

A spherical ball 86 is positioned within the confinement of each bore 84 so that it can translate simultaneously along the mid lines of the ball races 46 and 64.

The input shaft 12 has externally protruding splines 88 that mesh with the splines 56 that extend axially along the cylindrical bore 54 of the inner joint member 52.

The cylindrical bore 54 of the inner joint member 52 contains a reentrant groove 90 for the containment of a fingerlock retaining ring 92. A plurality of cantilevered resilient fingers 94 snap over a radially disposed ledge 96 that circumscribes the input shaft 12. Thus, the fingerlock retaining ring 92 prevents axial movement of the input shaft 12 with respect to the inner joint member 52.

Figure 2 is a part sectioned side view of the overall apparatus 10 that shows the universal joint in an angular drive attitude. For purposes of discussion, the output shaft 14, the attached hub 16 and the outer joint member 32 remain in fixed relationship to one another and do not move, other than rotatively. As depicted in Figure 2, the input shaft 12 has assumed a position so that its input axis 18 is angularly disposed

with respect to the output axis 20 of the output shaft 14. As the input shaft 12 moves to a new angular position, the inner joint member 52 also moves through the same angle since it is fixed with respect to the input shaft 12. As the input shaft 12 moves through a given angle, the spherical balls 86 translate along the most vertically oriented spherical ball 86 moves the furthest to the right while the lowest diametrically positioned spherical ball 86 moves correspondingly to the left along another pair of ball races 46 and 64. The remaining spherical balls 86 move correspondingly along the ball races 46 and 64. Of course, if a pair of spherical balls 86 lies on the input axis 18, there would be no translation along the ball races 46 and 64. The above discussion assumes that there is no rotation of the input and output shafts 12 and 14.

As the input shaft 12 and the inner joint member 52 articulate through a given angle, the ball cage 70 rotates a lesser amount as can be seen in Figure 2. It is important that the ball cage 70 always articulates so that the axis 98 of the bores 84 remains positioned so that the point L lies thereon. In this manner, a constant velocity will be achieved through the overall apparatus 10.

An examination of the lower spherical ball 86 in Figure 2 shows that it has moved to the left until it is in close proximity to the arcuate section 26 of the hub 16. Also, the lowermost portion of the ball cage 70 has moved to the left until it occupies part of the cavity defined by the frustoconical section 28. The ball cage 70 has contact with only the spherical balls 86, the interior spherical surface 38 of the outer joint member 32, and the exterior spherical surface 72 of the inner joint member 52.

The angular movement of the input shaft 12 is terminated when the input shaft 12 contacts a frustoconical beveled surface 100 of the outer joint member 32.

Figure 3 is a part sectioned side elevational view of the integral hub 16 and the output shaft 14. The output shaft 14 can be divided into cylindrical axial extents 102 and 104, each containing an arcuate array of longitudinally aligned splines 106. The hub 16, which is an extension of the output shaft 14, has an internal cavity defined by the arcuate section 26, the frustoconical section 28, and the spherical section 30. Since there is no undercutting required in the formation of the internal cavity of the hub 16, it can be formed by press or forging techniques.

Figure 4 is an end view of the hub cavity as viewed along lines 4-4 of Figure 3. The lip 24 is shown in its planar view along with the lines of intersection between the previously mentioned surfaces of the cavity within the hub 16.

Figure 5 is an elevational end view of the outer joint member 32 that shows the diametrically opposed pairs of grooves positioned on the interior spherical surface 38 of the outer joint member 32. As can be seen, the ball races 46 are not undercut; thus, they can be formed by press or forge techniques. If sintering techniques are employed in the fabrication of the outer joint member 32 then metal removal techniques need not be employed to form the spherical interior surface 38. The cross-sectional configuration of the ball race 46 is shown as circular with tangential parallel extensions 108 coupled thereto. While the extensions 108 are shown as parallel, they may, if desired, diverge slightly toward the input axis 18. Also, the arcuate cross-sectional portion of the ball race 46 can be slightly non-circular, providing for line contact with the spherical balls that translate therethrough.

Figure 6 is a sectional view taken along section lines 6-6 of Figure 5 that shows the curvilinear surface of the circular and linear sections 48 and 50. The interior spherical surface 38 is also shown.

Figure 7 is an end view of the inner joint member 52 that shows the pairs of diametrically opposed ball races 64 positioned on the exterior spherical surface 62 of the inner joint member 52. The number of ball races 64 equals the number of ball races 46 as previously shown in Figure 5. The cylindrical bore 54 contains the splines 56 which are in axial alignment with the input axis 18.

Figure 8 is a sectional view taken along section lines 8-8 of Figure 7 that shows the curvilinear mid line of the ball race 64 and the exterior spherical surface 62 of the inner joint member 52. The planar left and right ends 58 and 60 permit the employment of easy fabrication techniques as previously commented on.

<u>ASSEMBLY AND OPERATION</u>

The assembly of the overall apparatus 10 of the present invention is very straightforward. Also, the geometry of the components of the overall apparatus 10 permit automated assembly. The inner joint member 52 is positioned so that its left-hand edge, as viewed in Figure 1, is facing up. Next, the ball cage 70 is lowered concentrically, and in axial alignment, around the inner joint member 52 until the bores 84 are opposite the circular section 66 of the ball race 64. The spherical balls 86 are then inserted into each of the bores 84. As the spherical balls 86 move radially inward, they will contact the circular section 66 of the ball race 64 and remain stationary. The outer joint member 32 is then telescoped over the ball cage 70. The ball cage 70 is then moved into final axial alignment. The spherical balls 86 are now held against radially outward disengagement by the ball races 46. The cylindrical external surface 22 of the hub 16 is then moved into engagement with the internal cylindrical surface 36 of the outer joint member 32 and then immobilized therewithin. The immobilization technique can involve a press fit, welding, or a snap ring placement as depicted at 108a in Figure 2. At this time or subsequent thereto, the input shaft 12 can be inserted into the

cylindrical bore 54 so that the splines 56 and 88 slide into engagement. Upon full insertion of the input shaft 12, the resilient fingers 94 of the previously inserted retaining ring 92 engage with the ledge 96 on the input shaft 12, locking it into its final position.

During operation of the overall apparatus 10, a torque is applied to the input shaft 12, causing it and the spline coupled inner joint member 52 to rotate. The torque is then transmitted from the inner joint member 52 to the spherical balls 86 by contact with the ball races 64. The spherical balls 86 then transmit the torque to the outer joint member 32 via the ball races 46. Since the outer joint member is non-rotatively attached to the lip 24 of the hub 16, the hub 16 rotates along with the integrally attached output shaft 14.

When the input and output axis 18 and 20, respectively, are in alignment with one another, the spherical balls 86 will remain at one location along the ball races 46 and 64 during rotation of the overall apparatus 10. Since the spherical balls are centrally positioned within the ball races 46 and 64, the stresses are fairly well distributed through the outer joint member 32 and the inner joint member 52.

As the input shaft 12 and its accompanying input axis 18 assume an angular position or bending angle, such as 45°, with respect to the output shaft 14 and its output axis 20, the spherical balls 86 no longer track in a single circular path about the input axis 18. During one complete revolution of the overall apparatus 10, the spherical balls 86 will traverse nearly the entire length of the ball races 46 and 64. Since the spherical balls 86 are fixed against lateral movement with respect to the ball cage 70, the ball cage 70 not only rotates on its exterior and interior spherical surfaces 72 and 74 but, also, the ball cage must rotate when the input axis 18 shifts position from left to right about an axis that passes through the point L. The rotational axis for the ball cage 70 is perpendicular to the input

axis 18 only when the input and output axes 18 and 20 are in alignment. The amount and frequency of the rotation of the ball cage 70 about its axis depends on the frequency and magnitude of the change in the angle as identified in Figure 2 by reference numeral 110. When the overall apparatus 10 is operating at a maximum bending angle, a maximum load occurs against the inside surface of the circular section 48 adjacent to the end 44 of the outer joint member 32. This point of maximum load is identified by numeral 112 in Figure 2. Since the design of the outer joint member 32 is thickest at the end 44, it can withstand the high loads induced at the maximum load point 112. Then, too, the increased overall cross-section of the outer joint member 32 at the end 44 reduces the amount of detection of the end 44 in a circumferential or hoop direction. The reduced circumferential elongation results in longer life and increased durability of the overall apparatus.

While the illustrative embodiment of the invention has been described in considerable detail for the purpose of setting forth a practical operative structure whereby the invention may be practiced, it is to be understood that the particular apparatus described is intended to be illustrative only, and that the various novel characteristics of the invention may be incorporated in other structural forms without departing from the spirit and scope of the invention defined in the appended claims. What is claimed is:

1. A constant velocity universal joint for use between two shafts for transmission of power from a driving shaft to a driven shaft comprising:

an inner joint member having an exterior spherical surface, an axis of symmetry, and an aperture located about said axis of symmetry;

drive means positioned within said aperture to facilitate rotation of said inner joint member;

a first plurality of axially aligned ball races formed in said exterior spherical surface of said inner joint member;

an outer joint member having one end, an interior spherical surface, and a centrally positioned aperture therethrough, said outer joint member being positioned in telescoped concentric relationship with respect to said inner joint member, said outer joint member further having a centrally positioned axis therethrough;

a second plurality of ball races formed in said interior spherical surface of said inner joint member;

a plurality of spherical balls interposed said inner joint member and outer joint member;

containment means interposed between said inner joint member and said outer joint member for the containment of said plurality of spherical balls, each ball of said plurality of spherical balls being in contact with said first and second plurality of ball races;

a hub attached to said one end of said outer joint member, said hub having a centrally positioned cavity therein; and

an output shaft formed as an integral part of said hub, said output shaft having an axis coincident with said centrally positioned axis of said outer joint member.

2. The constant velocity universal joint of Claim 1 wherein said drive means comprises an input shaft, said input shaft comprising a plurality of splines on one end thereof.

3. The constant velocity universal joint of Claim 2 wherein said drive means further comprises a plurality of splines positioned within said aperture of said inner joint member.

4. The constant velocity universal joint of Claim 1 wherein said containment means interposed between said inner joint member and said outer joint member is an apertured ball cage.

5. The constant velocity universal joint of Claim 1 wherein said containment means comprises an annular cage member having an outer surface, an inner surface spaced from said outer surface, a centrally positioned aperture having a central axis, and a plurality of circumferentially spaced radially aligned apertures interposed said inner and outer surfaces for the containment of said spherical balls.

6. The constant velocity universal joint of Claim 5 wherein said plurality of circumferentially spaced radially aligned apertures are of an even number.

7. The constant velocity universal joint of Claim 6 wherein said plurality of circumferentially spaced radially aligned apertures are arranged in diametrically opposite pairs perpendicular to said central axis of said centrally positioned aperture.

8. The constant velocity universal joint of Claim 7 wherein each of said apertures of said plurality of circumferentially spaced radially aligned apertures contains one of said spherical balls.

9. The constant velocity universal joint of Claim 8 wherein said outer surface of said annular cage member is an exterior spherical surface and further wherein said inner surface of said annular cage member is an interior spherical surface, said interior and exterior spherical surfaces being concentric with one another.

10. The constant velocity universal joint of Claim 1 wherein said first plurality of ball races in said inner joint

member have a minimum radial distance from said axis of said inner joint member adjacent to said hub.

11. The constant velocity universal joint of Claim 10 wherein each of said first plurality of ball races are comprised of a curved section and a linear section.

12. The constant velocity universal joint of Claim 1 wherein said second plurality of ball races in said outer joint member have a maximum radial distance from said axis of said outer joint member adjacent to said hub.

13. The constant velocity universal joint of Claim 12 wherein each of said second plurality of ball races are comprised of a curved section and a linear section.

14. The constant velocity universal joint of Claim 1 wherein said exterior spherical surface of said inner joint member is of greater radial extent from said axis of said inner joint member than said first plurality of ball races contained therein, and said interior spherical surface of said outer joint member is of lesser radial extent from said axis of said outer joint member than said first plurality of ball races contained therein.

15. The constant velocity universal joint of Claim 14 wherein said exterior spherical surface and said interior spherical surface are concentric with one another.

16. A constant velocity universal joint for use between two shafts for transmission of power from a driving shaft to a driven shaft comprising:

an inner joint member having an axis of symmetry, an exterior spherical surface, a central splined aperture located about said axis, and a first plurality of axially aligned ball races formed in said exterior spherical surface; said exterior spherical surface being of greater radial extent from said axis than said plurality of axially aligned ball races;

an input shaft, said input shaft having a plurality of splines positioned within said central splined aperture of said

inner joint member, said plurality of splines being oriented parallel to an axis of said input shaft;

an outer joint member, said outer joint member having one end, an interior spherical surface, and a centrally positioned aperture therethrough, said outer joint member being positioned in telescoped concentric relationship with respect to said inner joint member, said outer joint member further having a second plurality of ball races formed in said interior spherical surface and a central axis therethrough, said interior spherical surface being of lesser radial extent from said central axis than said plurality of ball races;

an annular ball cage member interposed between said inner joint member and said outer joint member for the containment of a plurality of spherical balls, said annular ball cage member having an outer surface, an inner surface spaced from said outer surface, a centrally positioned aperture, and a plurality of circumferentially spaced radially aligned apertures between said inner and outer surfaces for receiving one each of said spherical balls, said plurality of spherical balls each being in contact with said first and second plurality of ball races;

a hub attached to one end of said outer joint member, said hub having a centrally positioned cavity therein; and

an output shaft formed as an integral part of said hub, said output shaft having an axis coincident with said axis of said outer joint member.

17. The constant velocity universal joint of Claim 16 wherein said plurality of circumferentially spaced apertures in said annular ball cage member are of an even number.

18. The constant velocity universal joint of Claim 17 wherein said plurality of circumferentially spaced apertures are arranged in diametrically opposite pairs perpendicular to said axis of said centrally positioned aperture.

19. The constant velocity universal joint of Claim 16 wherein said annular ball cage member has interior and exterior spherical surfaces that are concentric with one another.

20. The constant velocity universal joint of Claim 16 wherein said first plurality of ball races in said inner joint member have a minimum radial distance from said axis of said inner joint member and further wherein said first plurality of ball races are comprised of a curved section and a linear section.

21. The constant velocity universal joint of Claim 16 wherein said second plurality of ball races in said outer joint member have a maximum radial distance from said central axis of said outer joint member and further wherein said second plurality of ball races are comprised of a curved section and a linear section.

22. The constant velocity universal joint of Claim 16 wherein said exterior spherical surface of said inner joint member and said interior spherical surface of said outer joint member are concentric with each other.

23. The constant velocity universal joint of Claim 16 wherein said hub and said outer joint member are united by a snap ring.

24. The constant velocity universal joint of Claim 16 wherein said outer joint member has a greater wall thickness on an opposite end most remote from said hub.

25. The constant velocity universal joint of Claim 16 wherein a retaining ring is interposed between said inner joint member and said input shaft.

26. A constant velocity universal joint for use between two shafts for transmission of power from a driving shaft to a driven shaft comprising:

an inner joint member, an exterior spherical surface having an axis of symmetry, a central splined aperture located about said axis, and a first plurality of axially aligned ball races formed in said exterior spherical surface, said first

plurality of ball races having a minimum radial distance from said axis of symmetry, said first plurality of ball races being comprised of curved and linear sections, said exterior spherical surface of said inner joint member being of greater radial extent from said axis than said first plurality of ball races;

an input shaft, said input shaft having a plurality of splines positioned within said central splined aperture of said inner joint member, said plurality of splines being oriented parallel to an axis of said input shaft;

an outer joint member having one end, an interior spherical surface and a centrally positioned aperture therethrough, said outer joint member being positioned in telescoped concentric relationship with respect to said inner joint member, said outer joint member further having a centrally positioned axis, a second plurality of ball races formed in said interior spherical surface, said second plurality of ball races having a maximum radial distance from said central axis, said second plurality of ball races being comprised of curved and linear sections, said outer joint member further having a greater wall thickness on an opposite end, said interior spherical surface being of lesser radial extent from said central axis than said second plurality of ball races;

an annular ball cage member interposed between said inner joint member and said outer joint member for the containment of a plurality of spherical balls, said annular ball cage member comprising an outer surface, an inner surface spaced from said outer surface, a centrally positioned aperture, and a plurality of circumferentially spaced radially aligned apertures of even number arranged in diametrically opposite pairs perpendicular to said central axis, said plurality of circumferentially spaced apertures each containing a spherical ball, each said spherical ball being in contact with said first and second plurality of ball races of said inner joint member and said outer joint member, respectively, said outer surface and said inner surface of said annular ball

cage member being spherical surfaces that are concentric with one another;

a hub attached to said one end of said outer joint member, said hub having a centrally positioned cavity therein; and

an output shaft formed as an integral part of said hub, said output shaft having an axis coincident with said axis of said outer joint member.

27. The constant velocity universal joint of Claim 26 wherein said exterior spherical surface of said inner joint member and said interior spherical surface of said outer joint member are concentric with each other.

28. The constant velocity universal joint of Claim 26 wherein said hub and said outer joint member are united by a snap ring.

29. The constant velocity universal joint of Claim 26 further comprising a retaining ring interposed between said inner joint member and said input shaft for mounting said inner joint member to said input shaft.

30. The constant velocity universal joint of Claim 26 wherein said output shaft has a plurality of spline sets on one end thereof, each spline set having splines circumferentially spaced apart and in axial alignment with said axis of said output shaft.

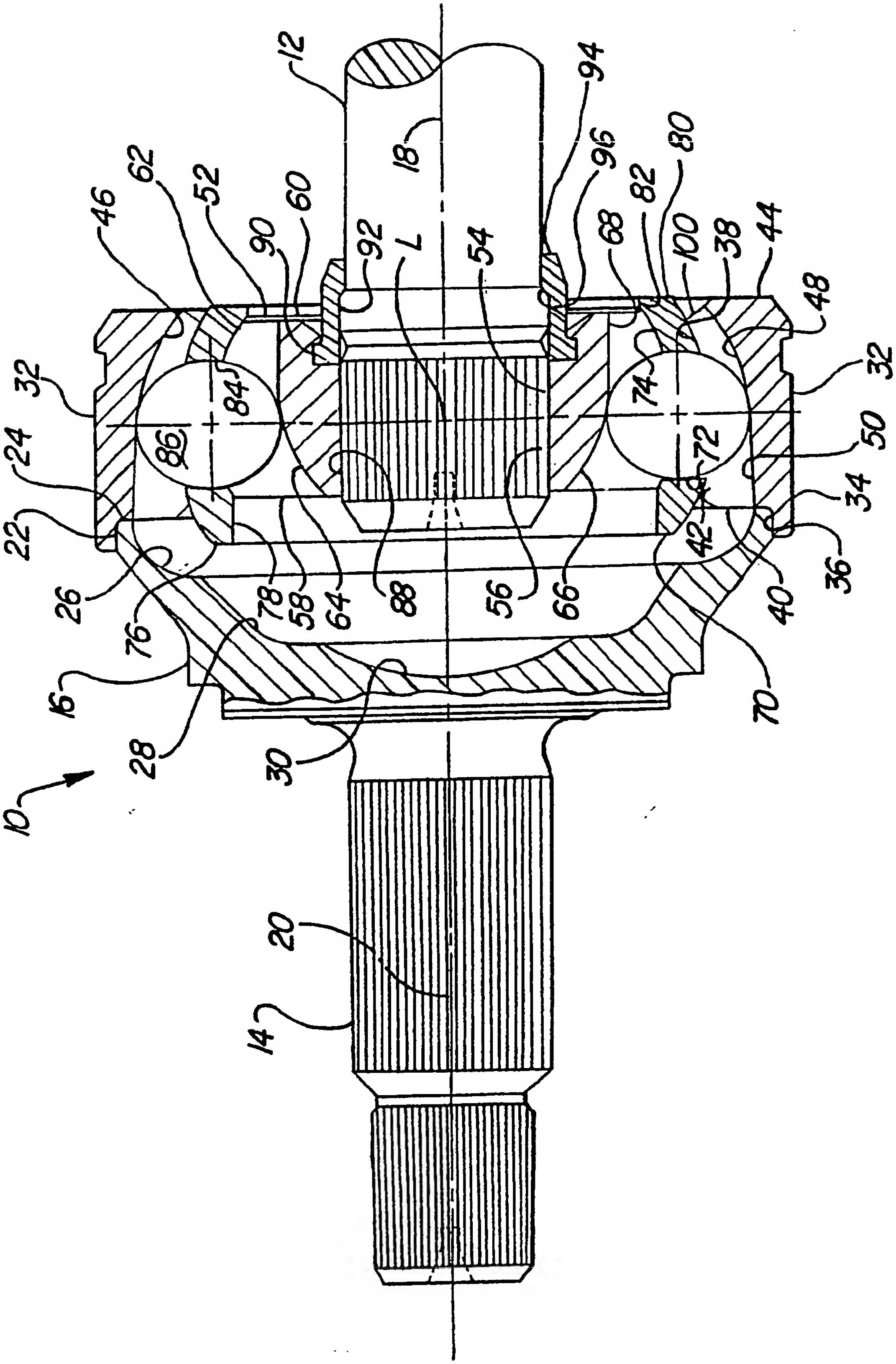
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Fig-1

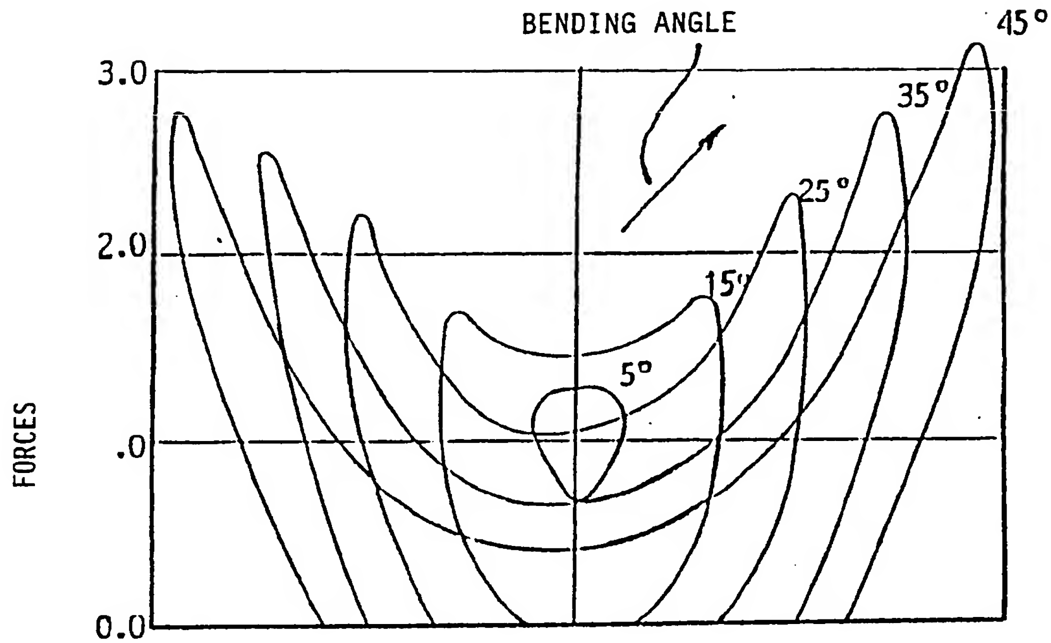


Fig-1B
PRIOR ART

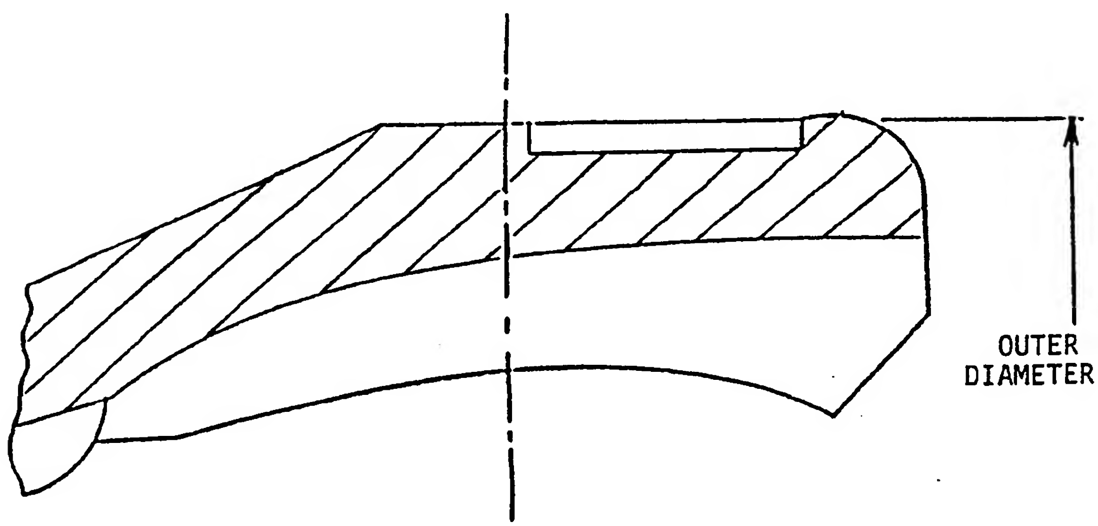
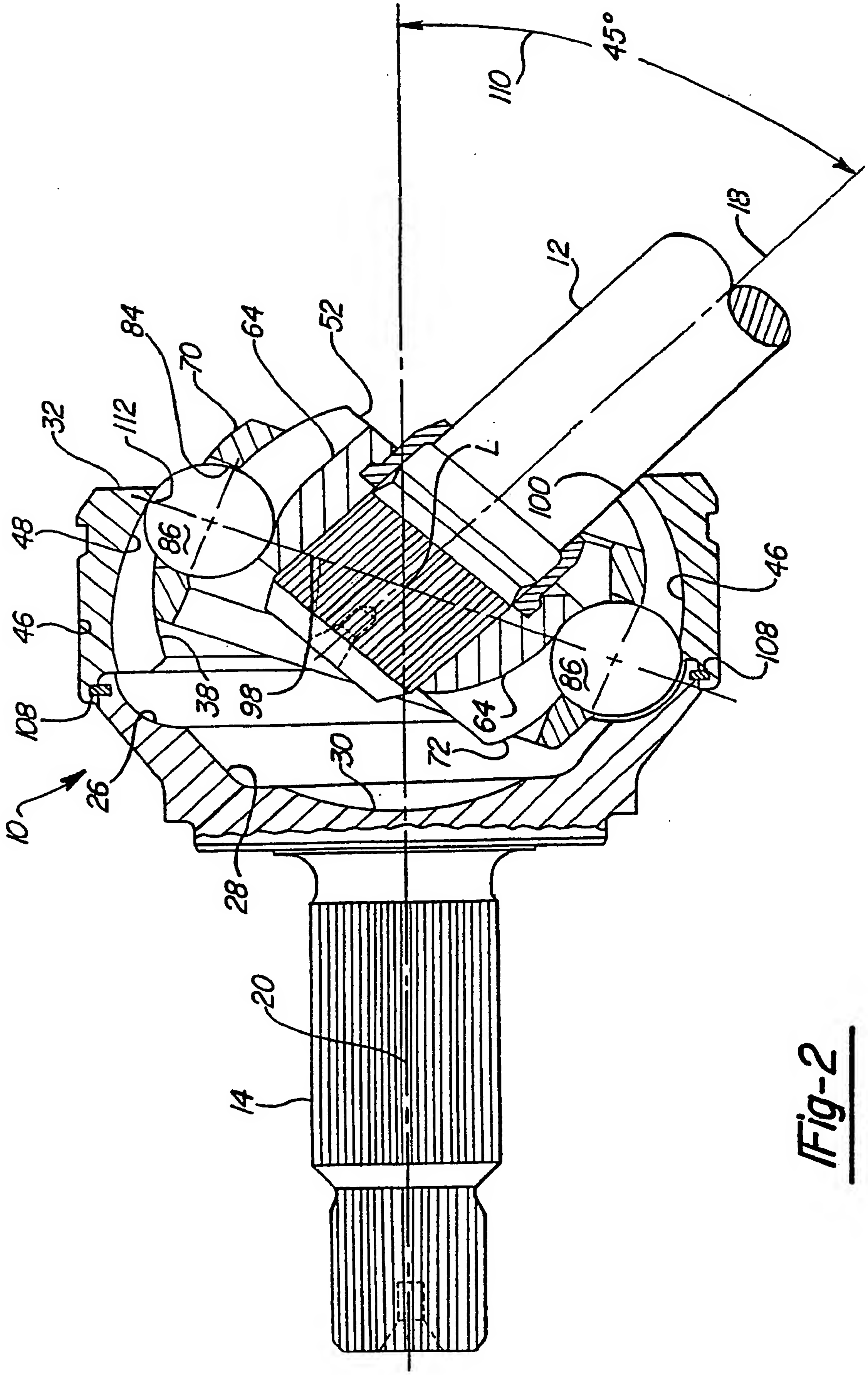


Fig-1A
PRIOR ART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12
84
70
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32
112
L
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100
46
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38
98
64
86
72
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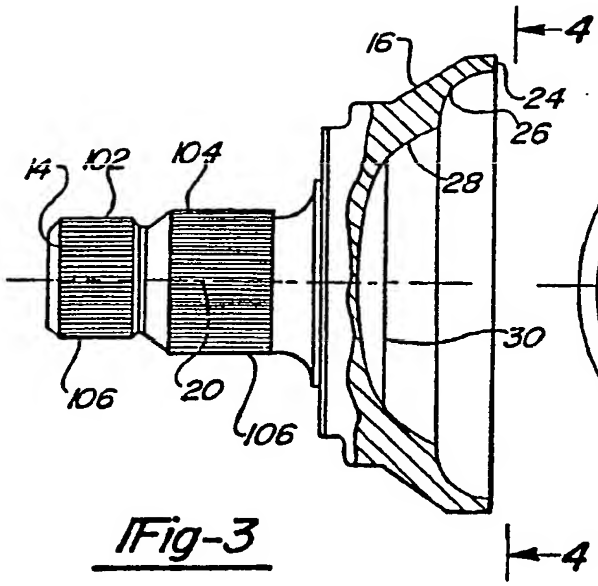
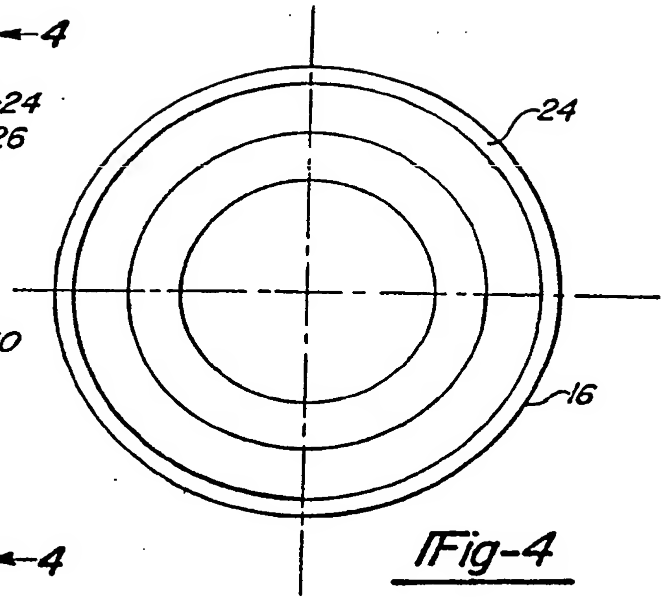
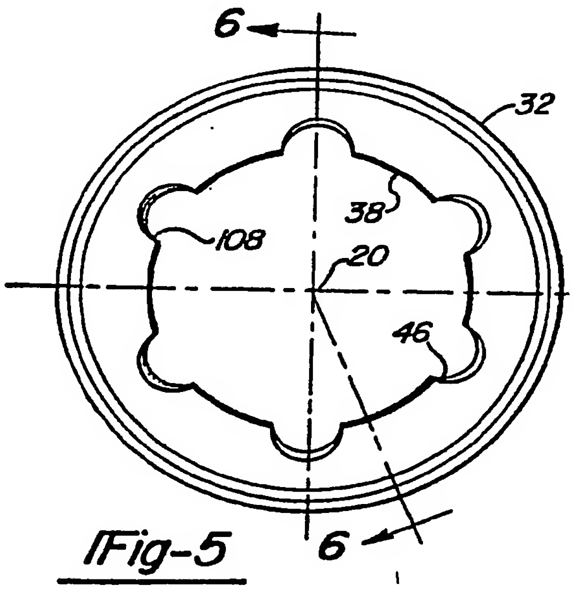
Fig-2



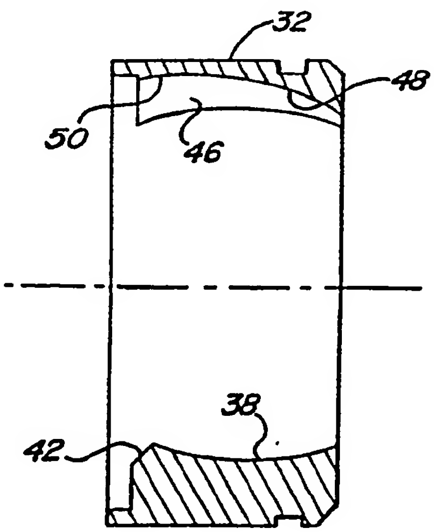
/Fig-3



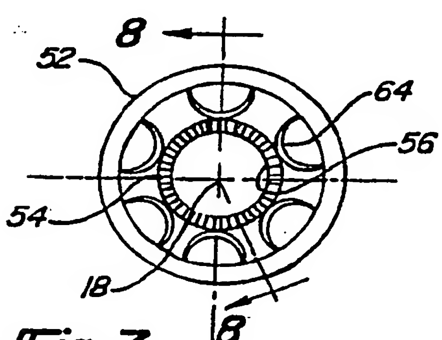
/Fig-4



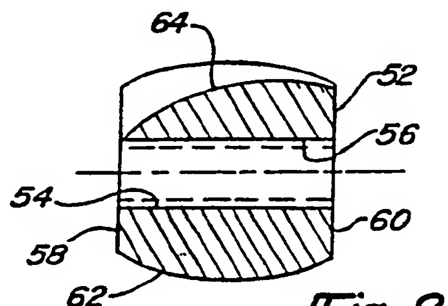
/Fig-5



/Fig-6



/Fig-7



/Fig-8

INTERNATIONAL SEARCH REPORT

International Application No PCT/US90/03654

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5) F16D 3/16,3/50
U.S. Cl. 464/145

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	464/143,144,145,906

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	US, A 1,665,280 RZEPPA 10 April 1928 (10.04.28) (Note page 1, lines 11-15, 23-27)	1-10,14-19,22, 24
X	US, A 3,324,682 Bendler 13 June 1967 (13.06.67)	1-9,14-19,22, 24
X Y	US, A 4,608,028 Welschof Et Al 26 August 1986 (26.08.86) (Note Figure 1 and that the hub is homogeneously connected to the outer joint member)	1-5,14-16,15-22, 25 1-30
Y	JP, A 55-72921 ITOU 28 November 1978 (28.11.78) (Note Figures 1 and 2)	1-30
Y	US, A 4,116,020 Aucktor Et Al 26 September 1978 (26.09.78) (Note groove orientation and column 5, lines 17-20)	10-13,23,24, 26-30

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
17 September 1990 (17.09.90)	15 NOV 1990
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	William G. Battista, Jr.

International Application No. PCT/US90/03654

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
Y	US, A 2,322,570 Dodge 22 June 1943 (22.06.43) (Note Snap Ring)	23,28
A	US, A 2,309,939 Dodge 02 February 1943 (02.02.43) (Note Snap Ring)	1-30
A	US, A 4,756,640 Gehrke 12 July 1988 (12.07.88) (Note resilient finger retaining ring)	1-30
A	US, A 3,879,960 Welschof Et Al 29 April 1975 (29.04.75)	1-30
A	US, A 4,188,803 Otsuka Et Al 19 February 1980 (19.02.80)	1-30
A	US, A 4,610,643 Krude 09 September 1986 (09.09.86)	1-30
A	US, A 1,916,442 Rzeppa 04 July 1933 (04.07.33) (Note six balls)	1-30
A	US, A 3,541,809 Howey 24 November 1970 (24.11.70) (Note six balls)	1-30